GAMMA-RAY LARGE AREA SPACE TELESCOPE (GLAST) PROJECT

SYSTEM ENGINEERING MANAGEMENT PLAN (SEMP)

August 12, 2003

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

433-PLAN-0014

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1.0 INTRODUCTION

1.1 PURPOSE

The Gamma-Ray Large Area Space Telescope (GLAST) Project Systems Engineering Management Plan (SEMP) defines the technical management approach to manage and execute GLAST Systems Engineering activities. This document covers the entire systems engineering life cycle of GLAST.

1.2 APPLICABLE DOCUMENTS

The following documents, or latest revision thereof, are applicable to the development of this plan.

433-PLAN-0001	GLAST Project Plan	
433-PLAN-0008	GLAST Program Plan (incl. App. A GLAST Level 1 Requirements)	
433-PLAN-0011	Independent Review Plan	
433-PLAN-0002	Risk Management Plan	
433-PROC-0001	CM Procedure	
433-SPEC-0001	GLAST Project Mission System Specification	
433-RQMT-0005	EMI Requirements Document	
NPD 8010.2	Use of the Metric System of Measurement in NASA Programs	CH-01
NPG 1000.2	NASA Strategic Management Handbook	
NPG 7120.5B	NASA Program and Project Management Processes and Requirements	
SP-610S	NASA Systems Engineering Handbook	
GPG 7120.2.2A	GSFC Project Management	
GPG 7120.4	Risk Management	
GPG 7120.5	Systems Engineering	
GPG 8700.1	Design Planning and Interface Management	
GPG 8700.4	Integrated Independent Reviews	

1.3 MISSION OVERVIEW

GLAST is a premier space-science experiment that will bridge the fields of astronomy and particle physics in the study of black hole particle jets and other high-energy phenomena using its two main instruments, the Large Area Telescope (LAT) and the GLAST Burst Monitor (GBM).

GLAST is an international collaboration of government agencies and academic institutions from the United States, France, Germany, Japan, Italy, and Sweden. The LAT is a joint project with NASA and the U.S. Department of Energy. The LAT will be constructed by Stanford University, the Stanford Linear Accelerator Center, the University of California, Santa Cruz, the Naval Research Laboratory, NASA Goddard Space Flight Center, and the international partners.

NASA Marshall Space Flight Center, along with the University of Alabama Huntsville and Germany will build the GBM. Southwest Research Institute (SwRI) will build the data processing unit (DPU) component of the GBM instrument. The overall mission management resides at NASA Goddard.

Spectrum Astro, Inc. is the spacecraft bus manufacturer and the observatory integrator. The spacecraft bus is based on the Spectrum Astro 200HP Rapid Spacecraft Development Office (RSDO) catalog bus.

The Mission Operations Center is located at GSFC and is a joint development between GSFC and Goldbelt-Orca, with Omitron, Inc providing support as sub-contractor.

GLAST is a high-energy gamma-ray observatory designed for making observations of celestial sources in the energy band extending from 20 MeV to 300 GeV with complementary coverage between 10 keV and 25 MeV for gamma-ray bursts. This mission will:

1) Identify and study nature's high-energy particle accelerators through observations of active galactic nuclei, pulsars, stellar-mass black holes, supernova remnants, gamma-ray bursts, Solar and stellar flares, and the diffuse galactic and extragalactic high-energy radiation.
2) Use these sources to probe important physical parameters of the Galaxy and the Universe that are not readily measured with other observatories, such as the intensity of infrared radiation fields, magnetic fields strengths in cosmic particle accelerators, and diffuse gamma-ray fluxes from the Milky Way and nearby galaxies, and the diffuse extragalactic gamma-ray background radiation.
3) Use high-energy gamma rays to search for a variety of fundamentally new phenomena, such as particle dark matter, quantum gravity, and evaporating black holes.

The GLAST mission will start with a one-year survey of the gamma-ray sky, after which the observation program will be determined by proposals from the international science community. The mission is being designed for a lifetime of five years, with a goal of 10 years of operations.

For more information on the GLAST mission and science objectives please reference the GLAST website at http://glast.gsfc.nasa.gov/

1.4 SYSTEM SEGMENT OVERVIEW

The overall GLAST system is composed of three major segments as described below and shown in Figure 1-1.

1.4.1 Flight Segment

The Flight segment consists of the spacecraft bus, the LAT and GBM instruments, and the launch vehicle.

1.4.2 Space-Ground Segment

The space-ground segment consists of the systems that connect the flight and ground systems. These include the TDRSS and GPS spacecraft, the White Sands, Malindi, and USN ground stations, and the associated services and facilities.

1.4.3 Ground Segment

The Ground Segment includes all of the facilities needed to plan, schedule, execute, monitor, and maintain the health and safety of the observatory during the mission. The Ground Segment also provides those facilities and equipment needed to receive, archive, and distribute processed or raw science data products to the investigator/user facilities. These include the Mission Operations Center, GLAST Science Support Center (GSSC), the LAT Instrument Operations Center (LIOC), the GBM Instrument Operations Center (GIOC) and the High Energy Astrophysics Science Archive Research Center (HEASARC).

1.5 DEFINITIONS

The definitions shown below in Table 1-1 will be used during the GLAST mission when defining the GLAST system.

Mission System	Definitions
Segments	Flight, Space-Ground Systems, Ground
Elements	Spacecraft, LAT, GBM, Launch Vehicle, Tracking and Data Relay Satellite System (TDRSS), Space Network (SN)/Ground Network (GN) Stations, Global Positioning System (GPS), MOC, GSSC, IOCs
Subsystems	Examples include: Structures and Mechanisms, Electrical Power, Guidance Navigation and Control (GN&C), Thermal Control, Propulsion, Communications, and Command and Data Handling (C&DH), Software, Tracker, Calorimeter, Anti-Cooincidence Deetector, Sodium Iodide Detectors, Bismuth Germinate Detectors

Table 1-1. GLAST Mission System Definitions

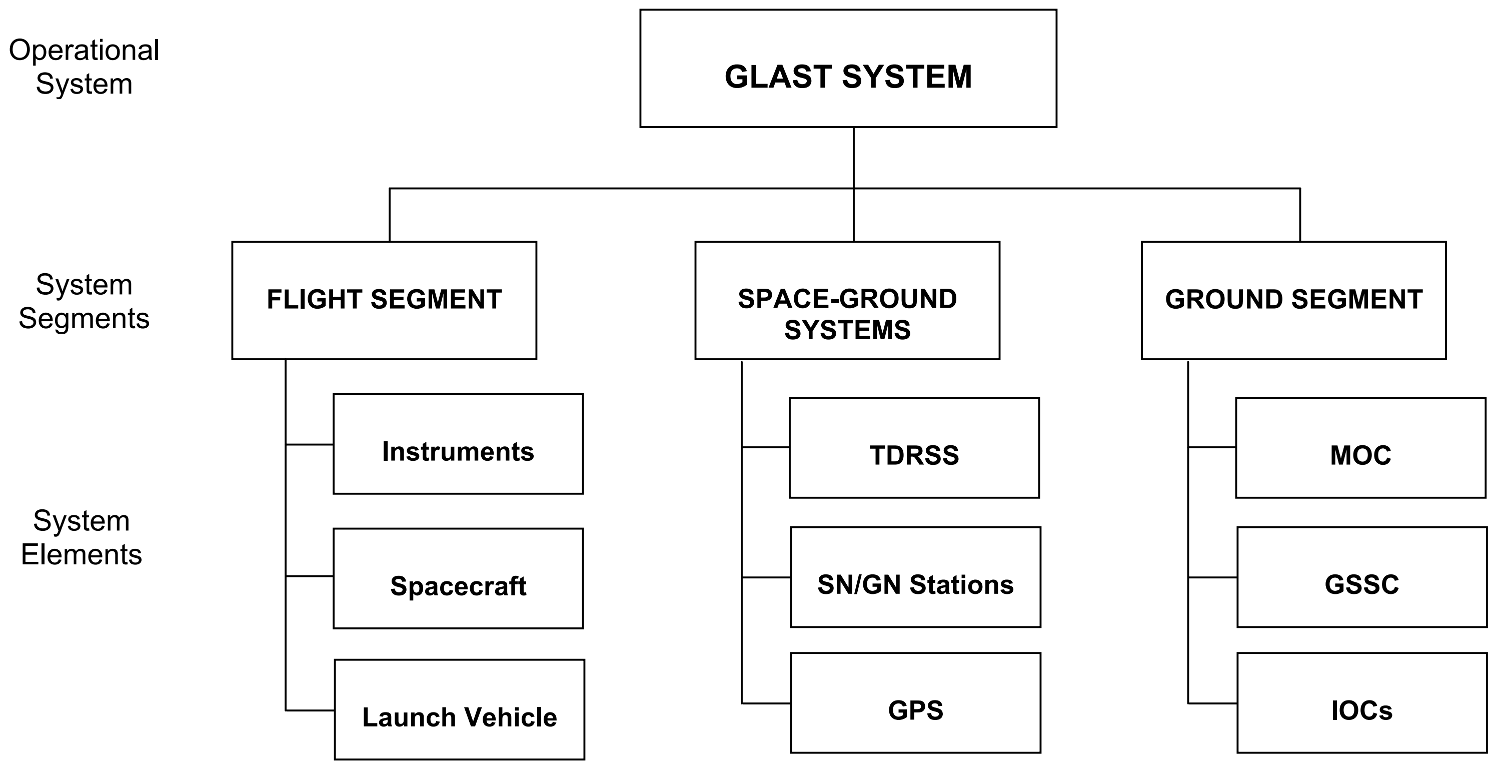

Figure 1-1. GLAST Segments

1.5.1 Observatory

The GLAST Observatory consists of the spacecraft and science instruments.

1.5.2 Spacecraft

The spacecraft provides the structural bus on which the two science instruments are mounted. The spacecraft provides electrical power, command and telemetry communication with the SN and GN, science and housekeeping data collection and storage, attitude determination and control, and, following the completion of the science mission, controlled re-entry via a propulsion system.

1.5.3 Instruments

GLAST carries two science instruments: the Large Area Telescope (LAT) and the Gamma-ray Burst Monitor (GBM).

1.5.3.1 LAT

The Large Area Telescope (LAT) is the primary instrument for GLAST and is a next-generation gamma-ray telescope. It has a wide field-of-view and will detect gamma-rays in an energy range from 20 MeV to 300 GeV. Visible light has an energy of roughly 2 eV (electron volts). GLAST will detect gamma rays by using a concept known as pair production. An incident gamma ray interacts with a layer of dense material in the telescope (tungsten in the case of GLAST), producing an electron and positron pair. A positron is an anti-electron, having all the properties of an electron except it is positively charged. The original photon (gamma ray) no longer exists, its energy having gone to the two resulting particles. These electron-positron pairs are then tracked through the telescope using silicon strip detectors. By tracking the "pairs", the source location of the incident gamma ray can be determined. A device called a calorimeter is then used to measure the energy of the incident gamma ray via the energies of the electron-positron pairs.

One problem gamma-ray detectors have to contend with is that cosmic rays entering the telescope can trick the detector into thinking it has detected a gamma ray, when in fact it was an unwanted cosmic ray. To combat this problem, the LAT will be covered by an anti-coincidence detector, which is transparent to gamma rays, but will register a hit when most cosmic rays pass through it.

1.5.3.2 GBM

The secondary instrument onboard GLAST, the GLAST Burst Monitor (GBM), is composed of two sets of detectors – 12 sodium iodide (NaI) scintillators and two cylindrical bismuth germanate (BGO) detectors – and will be used to aid in the study of gamma-ray bursts. The GBM extends the energy range of GLAST for observing bursts down to roughly 10 keV, providing the broadest energy range coverage ever on a single spacecraft. It will also provide onboard triggers and approximate locations for bursts that the LAT cannot see. The spacecraft can then be re-pointed to observe any delayed high-energy emission from the burst.

1.5.4 Ground Operations

The Mission Operations Center (MOC) will control the spacecraft by transmitting commands, and receiving the telemetry. The MOC will perform Level 0 processing, which removes transmission artifacts from the telemetry, and then will transmit these data to the other organizations. Each instrument team will maintain its own Instrument Operations Center (IOC) which will monitor the health of its instrument, take remedial action if necessary, perform the Level 1 processing, and support the instrument team's scientific studies. The two IOCs will transmit the Level 1 data and other data products to the GSSC; the GSSC will have a backup capability for performing Level 1 processing. The GSSC and the IOCs will have joint responsibility for the definition of the relevant science analysis tools and for the representation of the instrument response functions; GSSC scientists will participate in the development of the science tools. The GSSC will be responsible for supporting the astronomical community's use of GLAST data by running the guest investigator (GI) program, providing analysis software and expertise, and disseminating GLAST data and results. The GSSC will be responsible for the mission's science observation timeline. Finally, the GSSC will archive the mission's data.

1.6 PROJECT SCHEDULE

The Project Schedule can be found on the Project website at http://glast.gsfc.nasa.gov/project/.

1.7 SYSTEM ENGINEERING LIFE CYCLE AND REVIEWS

The System Engineering Life Cycle is defined within Goddard Procedure and Guideline (GPG) 7120.2, Project Management, as a set of phases – Formulation, Approval, and Implementation. The GLAST SEMP uses the familiar Pre-phase A, Phase A, Phase B, Phase C, and Phase D terminology described by the NASA Systems Engineering Handbook, SP-610S. This section describes each phase and shows the major reviews associated with each phase and the phase transitions. Figure 2-1 includes an illustration of these phases.

GLAST utilizes a Project Formulation Schedule to assist in schedule analysis and monthly reporting to GSFC Center Management. The schedule identifies key activities, or "gates", that are agreed upon between the Project Manager and GSFC Center Management prior to schedule baselining. Significant systems engineering milestones and reviews are contained in the GLAST Project Plan.

1.8 CONCEPT STUDIES

Pre-Phase A: Advanced Studies – The advanced studies occurs prior to the initiation of the GLAST System Engineering Life Cycle. Although not a part of the life cycle, advanced studies serve as the first step in determining new and potentially promising missions deserving of further study. These studies support the establishment of a suitable project through exploring perceived needs and potential solutions to meet them. The Pre-Phase A function must be completed prior to initiating the Formulation phase of the life cycle.

1.8.1 Major Pre-Phase A Gate

The major technical review to transition from Pre-Phase A to Phase A is the Mission Concept Review (MCR). The purpose of this review is to demonstrate that the mission objectives are complete and understandable; to confirm that the mission concept demonstrates technical and programmatic feasibility of meeting the mission objectives; and to confirm that the customer's mission need is clear and achievable.

The Formulation Authorization Document (FAD) is a major programmatic gate of the life cycle process, which is the primary input to the GLAST Project formulation sub-process. It authorizes the formulation of the project whose goal will fulfill part of NASA's Strategic Plan.

1.9 FORMULATION

Phase A and Phase B comprise the Formulation portion of the System Engineering life cycle. Proper planning during the Formulation period is essential to the successful execution of the Implementation phase. Phase A, or preliminary analysis, determines whether a candidate mission is needed, feasible, and compatible with the NASA strategic plan.

Phase B, or the definition phase, thoroughly defines the project requirements and provides sufficient detail definition of the mission to establish a baseline design capable of meeting the mission needs.

1.9.1 First Spacecraft Accommodation Study

The GLAST 2000 Spacecraft Accommodation Study employed two vendors to determine the feasibility of basing the GLAST observatory on one or more existing spacecraft designs. The goal of the first accommodation study was the determination of the range of suitable concepts for implementing the mission.

1.9.2 Phase A Reviews

The GLAST System Requirements Review (SRR) is a formal review chaired by the GSFC Flight Assurance Office. The SRR is held to ensure that the objectives and requirements of the GLAST mission are understood. It also confirms that the system-level requirements meet the mission objectives and that the system level specifications are sufficient to meet the project objectives. This review is held a few months prior to the beginning of Phase B.

1.9.3 Major Phase A Gate

The Initial Confirmation Review is the major gate between Phase A and Phase B. The mission concept including requirements, operations concept, and architecture and design is reviewed at a high level during this review.

1.9.4 Second Spacecraft Accommodation Study

The GLAST 2001 Spacecraft Accommodation Study employed four vendors to provide a design for the GLAST mission based on a current or future RSDO Rapid II Catalog spacecraft bus. The contractors studied modifications in the design of their spacecraft bus in sufficient detail to provide estimates of mass, power, thermal, and mechanical interfaces. The contractors were required to identify specific accommodations of the LAT and GBM instruments. The priorities of this study included producing detailed mission-specific GLAST designs, with supporting analyses, and mathematical models at near-PDR quality.

1.9.5 Phase B Reviews

The LAT and GBM Preliminary Design Reviews (PDR) demonstrates that the instrument architecture, designs, and operations concept developed during Formulation have been validated by enough technical analysis and design work to establish a credible, feasible design. The PDR also demonstrate that the instrument architecture and design meet all requirements; the best design options have been selected from trade studies and analyses; internal and external interfaces are identified and understood; risk management has been integrated into the design and development activities; and prioritized risk areas have mitigation approaches defined.

The Spacecraft System Requirements Review (SRR) is held to ensure that the objectives and requirements of the GLAST spacecraft are understood. It also confirms that the system-level requirements meet the mission objectives and that the system level specifications are sufficient to meet the project objectives. This review is held two months after the awarding of the spacecraft contract.

The spacecraft Preliminary Design Review (PDR) demonstrates that the spacecraft system architecture, designs, and operations concept developed during Formulation have been validated by enough technical analysis and design work to establish a credible, feasible design. The PDR also demonstrate that the spacecraft architecture and design still meet all system requirements; the best design options have been selected from trade studies and analyses: internal and external interfaces are identified and understood; risk management has been integrated into the design and development activities; and prioritized risk areas have mitigation approaches defined.

1.9.6 Major Phase B Gate

The Mission Preliminary Design Review (MPDR) is a major gate between Phase B and Phase C/D. It demonstrates that the system architecture, designs, and operations concept developed during Formulation have been validated by enough technical analysis and design work to establish a credible, feasible design. The MPDR also demonstrates the following: the GLAST mission architecture and design still meets all system requirements; the best design options have been selected from trade studies and analyses: internal and external interfaces are identified and understood; risk management has been integrated into the design and development activities; and prioritized risk areas have mitigation approaches defined.

The other two major gates between Phase B and Phase C/D are the Non-Advocate Review (NAR) and the Mission Confirmation Review (MCR). The NAR provides an independent verification of GLAST's program and project plans, life-cycle cost status, and readiness to proceed to the implementation phase. The MCR evaluates the readiness of GLAST to transition from formulation to implementation including: the establishment of success criteria and acceptable risk; an acceptable project plan that includes a commitment to people, facilities, travel and other Center resources; adequate technical margins and resource reserves; and the ability to implement the mission in a disciplined manner and within the resource and schedule constraints identified.

1.10 IMPLEMENTATION

Two phases comprise the Implementation portion of the System Engineering life cycle, Phase C (detailed design) and Phase D (fabrication and integration). The purpose of Phase C is to establish a complete design that is ready to fabricate, integrate, and verify. The purpose of Phase D is to build, integrate and verify the system designed in Phase C, deploy it, and prepare for operations.

1.10.1 Phase C Reviews

The LAT and GBM Critical Design Reviews (CDRs) confirm that the instrument system, subsystem, and component design, derived from the preliminary design, is of sufficient detail to allow for orderly hardware/software manufacturing, integration, and testing, and represents acceptable risk. Successful completion of the CDR freezes the design. These occur early in Phase C to allow longer manufacturing and testing phases for the instruments than is required for the RSDO spacecraft and are supported by longer formulation phases for the instruments.

The Ground System Requirements Review (SRR) is held to ensure that the objectives and requirements of the total ground system are understood. It also confirms that the system-level requirements meet the mission objectives and that the system level specifications are sufficient to meet the project objectives. This review is held one to two months after the Mission PDR.

The Ground System Preliminary Design Review (PDR) demonstrates that the ground system architecture, design, and operations concept have been validated by enough technical analysis and design work to establish a credible, feasible design. The PDR also demonstrates that the ground system architecture and design still meet all system requirements; the best design options have been selected from trade studies and analyses: internal and external interfaces are identified and understood; risk management has been integrated into the design and development activities; and prioritized risk areas have mitigation approaches defined. This review is held approximately six months after the Ground SRR.

The spacecraft Critical Design Review (CDR) confirms that the spacecraft's system, subsystem, and component design, derived from the preliminary design, is of sufficient detail to allow for orderly hardware/software manufacturing, integration, and testing, and represents acceptable risk. Successful completion of the CDR freezes the design, and is held just prior to the end of Phase C.

1.10.2 Major Phase C Gate

The Mission Critical Design Review (MCDR) confirms that the project's system, subsystem, and component design, derived from the preliminary design, is of sufficient detail to allow for orderly hardware/software manufacturing, integration, and testing, and represents acceptable risk. Successful completion of the MCDR freezes the design, and concludes Phase C.

1.10.3 Phase D Reviews

The Ground System Critical Design Review (CDR) confirms that the design of the overall ground system and the individual ground system elements is of sufficient detail to allow for orderly hardware/software purchasing, integration, and testing, and represents acceptable risk. Successful completion of the CDR freezes the design, and is held approximately six months after the Ground System PDR.

The Mission Operations Review (MOR) is a formal review chaired by the GSFC Flight Assurance Office and is primarily focused on defining the plans and schedule for flight operations preparations, such as the development and validation of the command procedures and the use of mission operations simulations. The MOR also addresses the status of the ground system.

The Pre-Environmental Review (PER) is a major gate that occurs before the start of environmental testing of the observatory. It establishes readiness of the system for test and evaluates the environmental test plans. PERs are held for the LAT and GBM separately, and for the GLAST observatory

The Operations Readiness Review (ORR) is held to demonstrate that the major flight operations readiness activities described in the MOR have been completed, or nearly completed. Those activities that remain to be accomplished are described in detail (e.g., additional launch rehearsals). All operations products, such as command procedures and the telemetry and command data base, are expected to be validated, under configuration management control, and ready for operations use. The ORR also addresses the readiness of the ground system to support operations.

The Pre-Shipment Review (PSR) is a major gate of the life cycle process and is used to present status of systems prior to shipment. It is a technical and programmatic review conducted prior to shipment of the observatory to the launch site. It establishes readiness to ship flight hardware, and is also a review of launch site activity plans. PSRs are held for the LAT and GBM separately, and for the GLAST observatory.

The Launch Readiness Review (LRR) is used to demonstrate readiness for launch and operations. It is a formal review to assess the overall observatory readiness to support mission objectives.

The Flight Readiness Review (FRR) examines tests, demonstrations, analyses, and audits that determine the observatory's readiness for a safe and successful launch and for subsequent flight operations. It also ensures that all flight and ground hardware, software, personnel, and procedures are operationally ready.

2.0 KEY SYSTEMS ENGINEERING FUNCTIONS

Key Systems Engineering functions during both the Formulation and Implementation phases are shown in Figure 2–1. The major Systems Engineering elements of the Formulation Phase include requirements identification and management, operations concept definition, and architecture and design synthesis. The operations concept definition, architecture and design synthesis, and requirements analysis are generally done in parallel. Each activity contributes to the refinement of the others.

The following paragraphs in this section describe the execution of the major Mission Systems Engineering processes and products that will support the GLAST Formulation Phase.

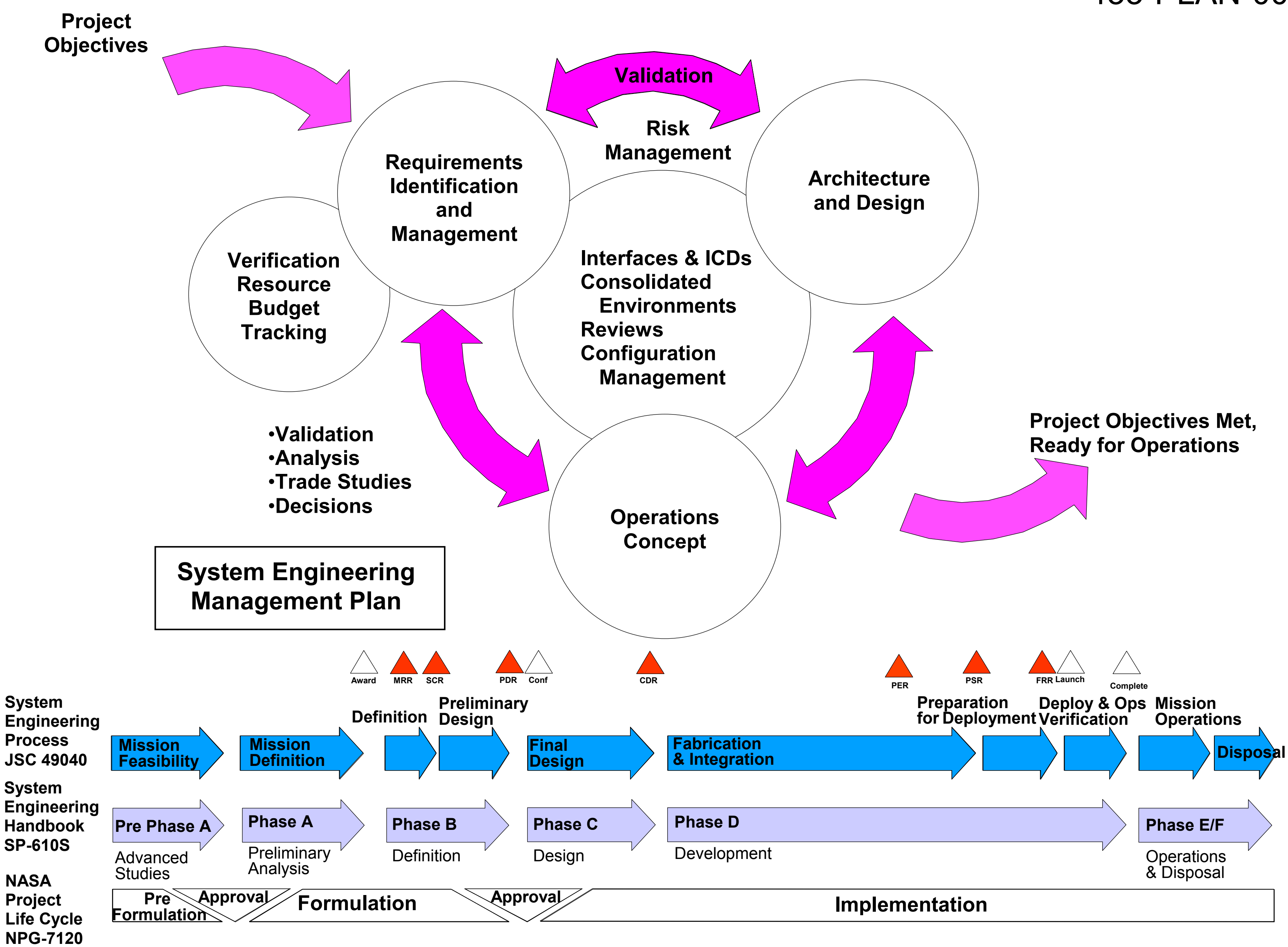

Figure 2-1. GLAST Key System Engineering Functions

2.1 REQUIREMENTS IDENTIFICATION AND ANALYSIS

2.1.1 Requirements Definition

The following definitions will be used during the GLAST mission when defining requirements.

System and Engineering Levels	Requirements Definition
Program, Project, HQ	Level 1
Mission, System, Segment	Level 2
Spacecraft, Instrument, Ground System Element	Level 3
Subsystem	Level 4

Table 2-1 GLAST Mission Requirements Definition

The GLAST mission requirements are organized into a hierarchy and provide the mechanisms for specifying what is necessary down to the lowest level of the system. Figure 2-2 shows how the requirements hierarchy is structured. The Project Systems Engineering Team is responsible for assigning each Level 1 and 2 requirements to an owner. Each requirement is assigned an owner by SRR. The owner is responsible for specifying the method of verification no later than PDR.

The GLAST requirements are also organized into four categories: functional requirements, performance requirements, interface requirements, and mission assurance requirements. Functional requirements are concise statements of what a system must do to satisfy its objectives. Performance requirements are concise statements of how well a system must perform its functions to satisfy its objectives. The performance requirements will be attached underneath their respective functional requirement and *not* in a separate performance requirements document. Interface requirements are concise statements that specify the exact nature of both sides of an interface between mission elements or subsystems. Mission assurance requirements specify safety, verification, Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC), contamination, materials, parts, processing, lubrication, reliability, and quality requirements.

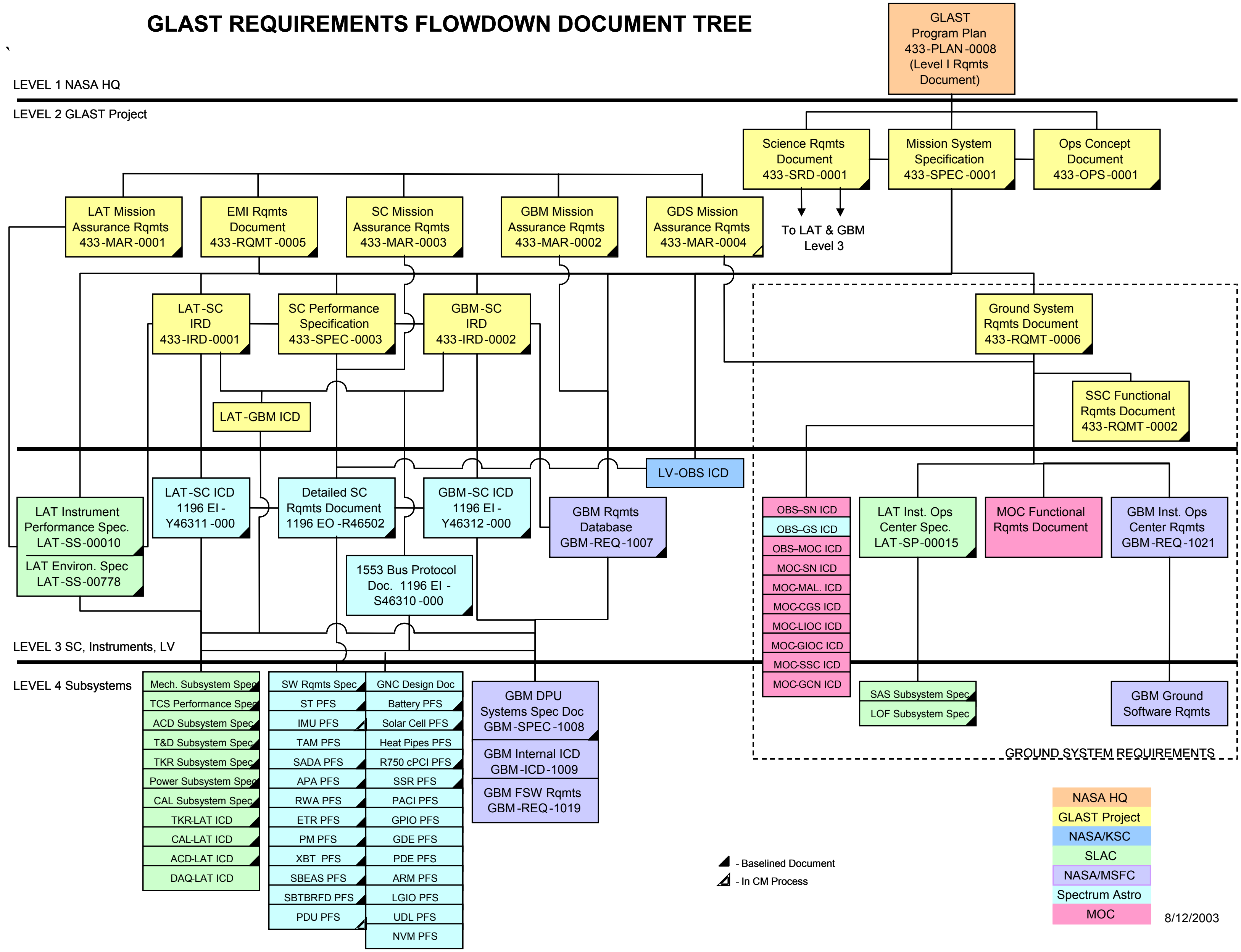

Figure 2-2. GLAST Requirements Documentation Tree

2.1.2 Requirements Between Elements

Some requirements flow between elements or are common amongst all elements. These requirements will be documented in the Mission System Specification (MSS) or in one the following documents:

- Interface Requirements Documents
- Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC) Requirements Document

2.1.3 Requirements Management

The Project System Engineering Team maintains a DOORS database for tracking GLAST Level 1, 2, and 3 requirements. The Mission System Engineering Manager (MSEM) and each element System Engineer (SE) is responsible for providing inputs to this common database including the requirement, owner, parent requirement, rationale, verification method, verification results, and status. The requirements are placed under configuration control and are managed by a Project Configuration Control Board (CCB).

Each Project Element maintains its own database for tracking their Level 3 and 4 requirements. The requirements are placed under configuration control and are managed by a Project Element Configuration Control Boards (CCB). All Level 3 requirement changes initiated by Project Elements that affect Level 1 and 2 requirements require approval by the Project CCB.

2.1.4 Requirements Validation

Requirements validation ensures that the mission architecture, design, and the operations concept meet the requirements. It asks the question "did we build the right system?" Requirements validation is an ongoing process within the cyclical refinement of the operations concept, mission architecture and design, and requirements management. The Project office systems engineering Team validates the requirements after the baseline mission and system architecture and operations concept is established and the MSS is stable. The MSS, mission architecture, and operations concept are updated simultaneously to reflect consistency.

A key tool in the requirements validation process is requirements analysis and traceability flowdown. This process decomposes or allocates requirements to successively lower levels of design. Each lower level requirement is also analyzed to ensure that it has a parent requirement. During the validation process, the Project Systems Engineering Team makes sure each Level 1, 2, and 3 requirement is verifiable, achievable, and traceable to a higher-level requirement or science objective. Systems Engineering Teams for each of the mission elements performs the same function for the Level 3 and 4 requirements.

2.1.5 Requirement Products

2.1.5.1 Level 1 Requirements Document

The GLAST Level 1 Requirements Document serves as the top level for the requirements flow-down. It defines science requirements, mission parameters, constraints, and programmatic boundaries (e.g., top-level science and mission requirements, external agreement requirements, and NASA/DOE constraints).

A requirements team, with members from the Project Systems Engineering Team, NASA, and DOE draft the Level 1 Requirements Document. The Level 1 Requirements Document is signed off at the Phase A-B Confirmation Review.

2.1.5.2 Science Requirements Document (SRD)

The SRD establishes the science objectives of the GLAST mission and sets functional and performance requirements for the instruments and observatory to meet the science objectives. The SRD is approved by the Project Scientist, the Project Manager, the LAT Principal Investigator, and the GBM Principal Investigator.

2.1.5.3 Mission System Specification (MSS)

TThe MSS contains both functional and performance requirements which, when met by the system, will satisfy the Level 1 requirements and mission objectives. The MSS contains all requirements that cross between elements including error allocations, control loops, etc, and provides the top-level requirements for the lower-level documents. Also, the MSS contains a verification matrix describing how each requirement is verified. The MSS is reviewed by the Project technical team under the leadership of the systems engineering team and baselined under CM prior to Mission SRR. The MSS is approved by the Project Scientist and the Project Manager, with concurrence by the LAT Principal Investigator, and the GBM Principal Investigator. From this point the systems team continuously refines and validates the MSS during the formulation phase.

2.1.5.4 LAT Instrument Performance Specification

The LAT Instrument Performance Specification defines the functional requirements for the LAT instrument and allocation of Level 3 requirements to the instrument subsystems. The verification methods of each requirement are identified.

2.1.5.5 GBM Requirements Database

The GBM requirements database is built from forms within FileMaker Pro 5.0. All requirements for the GBM instrument are captured within this database. There are sections for each subsystem. The requirements for the GIOC are also captured in the requirements database. This database is keyed by requirement number. Also included are a title and description of the requirement. Parent and Child requirements are tracked for each requirement. Verification method, location, criteria, and description are captured for each requirement along with compliance data and any non-conformances. Tables and figures may easily be added to any requirement. A verification matrix is included in the database which also captures verification method and test procedure or analysis necessary to close each requirement. Various reports can be generated to status the requirements and conformance data.

2.1.5.6 Spacecraft Performance Specification (SPS)

The SPS contains both functional and performance requirements for the GLAST spacecraft which, when met, will satisfy the Level 1 and 2 requirements and mission objectives. The SPS contains driving requirements for all spacecraft subsystems. The SPS is approved by the Project Manager.

2.1.5.7 Spacecraft Detailed Requirements Document (SDRD)

The SDRD specifies the detailed integrated system and subsystem requirements of the spacecraft. To avoid duplication, Interface Control Document entries (instrument, launch vehicle, ground system, etc.) are not repeated in the detailed spacecraft requirements document. The SDRD documents the top-down traceability of all spacecraft requirements as well as the linkages between lower level requirements on different subsystems to document the validation of the spacecraft requirements and allow the assessment of any proposed changes in requirements (including the addition of new and derived requirements). The SDRD includes a detailed verification matrix for the performance verification of the integrated spacecraft requirements. The matrix shows the approach used to verify the requirements, including the method of verification (test, analysis, inspection, demonstration) as well as the level of verification (component, subsystem, integration, observatory, on-orbit, etc.)

2.1.5.8 Ground System Requirements Document (GSRD)

This specification captures the GLAST ground system functional, interface, and performance requirements. It is comprised of system-level requirements that apply across all elements and element-level requirements. The verification methods of each requirement are identified.

2.1.5.9 Mission Operations Center Functional Requirements Document

This specification captures the GLAST MOC system requirements. This encompasses the system level requirements and the functional requirements for the MOC. The verification methods of each requirement are identified.

2.1.5.10 LAT Instrument Operations Center Specification

This specification captures the GLAST LAT system requirements for the ground-based systems provided by the LAT project. This encompasses the system level requirements and the functional requirements for the LAT Instrument Operations Center. The verification methods of each requirement are identified.

2.1.5.11 GBM Instrument Operations Center Requirements Document

This specification captures the GLAST GBM system requirements for the ground-based systems provided by the GBM project. This encompasses the system level requirements and the functional requirements for the GBM Instrument Operations Center. The verification methods of each requirement are identified.

2.1.5.12 Science Support Center Functional Requirements Document

This document defines the functional requirements that must be met by the GLAST Science Support Center (SCC). The document also identifies verification methods for each requirement.

2.1.6 Requirements Reviews

The GLAST System Requirements Review (SRR) is a formal review chaired by the GSFC Flight Assurance Office. The SRR is held to ensure that the objectives and requirements of the GLAST mission are understood. It also confirms that the system-level requirements meet the mission objectives and that the system level specifications are sufficient to meet the project objectives. The SRD and MSS are formally reviewed at the SRR.

The observatory SRR is a Project level review describing how Spectrum Astro's requirements process, system engineering, concept for developing the LAT and GBM interface control documents, concept for accommodating the instrument interfaces, safety, quality, reliability, and overall program plan meet the GLAST mission requirements. The objective of this review is to assure that the objectives and requirements of the observatory are understood and that the proposed approach will meet these requirements. The emphasis is on the requirements documented in the SRD, the MSS, the SPS, the IRDs, and other requirements documents, how they flow down and how they support the science objectives, and the definition of the major system interfaces.

2.2 OPERATIONS CONCEPT DEVELOPMENT

The Operations Concept definition begins in Pre-Phase A and a baseline is established at the end of Phase A. It is developed in parallel with the architecture and design activities and the requirements flow-down. The Operations Concept defines and addresses the following: ground versus flight allocation, operational modes and configurations (e.g., science, launch, checkout, calibration, etc.), data flow diagrams, storage and downlink, ground station utilization, and operations testing prior to launch. The Operations Concept is refined throughout the mission life cycle and eventually becomes the GLAST Operations Plan.

2.2.1 Operations Concept Document

The GLAST Operations Concept Document defines the entire range of operations for the GLAST mission. This includes spacecraft, instrument, space/ground communications, ground station, and operation center operations. Processing, distribution and archiving of GLAST data is also described. The Systems Engineering team and the Ground Segment team guide the development of the Operations Concept Document. The Operations Concept Document is approved by the Project Scientist and the Project Manager, with concurrence by the LAT Principal Investigator, and the GBM Principal Investigator.

2.2.2 Operations Concept Reviews

There are two major reviews conducted related to the Operations Concept activities during Formulation: the System Requirements Review (SRR) and the Mission Operations Concept (MOC) Peer Review. The SRR is at the end of Phase A and ensures that the operations requirements are complete. The MOC peer review is held in Phase B and ensures that the baseline Operations Concept meets the requirements and is defined in enough detail as to proceed to Phase C without risk of major changes.

2.3 MISSION ARCHITECTURE AND DESIGN

The Architecture and Design definition begins in Pre-Phase A and a baseline is established at the end of Phase A. It is developed in parallel with the Operations Concept activities and the requirements flow-down. This activity decomposes the total system into its major parts that then become the hierarchy for lower level interfaces and specifications.

The Project Systems Engineering Team is the keeper of the baseline architecture. The architecture and design specification and block diagram is formally reviewed at the SRR and a baseline established. Once the baseline is established, the architecture and design is under Configuration Control.

2.3.1 Architecture and Design Products

2.3.1.1 Architecture and Design Specification. The Architecture and Design Specification is a description of the total system and its decomposed major parts. The major parts of the system include the spacecraft, instruments, ground system, support subsystems and boxes as well as hardware and software functions. The major parts then become the hierarchy for lower level interfaces and specifications. The Architecture and Design Specification also includes a list of Interface Control Documents (ICDs) that need to be produced. The GLAST Architecture and Design Specification is documented in the Mission System Specification (MSS).

2.3.1.2 Trade Studies.

Trade studies and analysis are conducted as part of the two spacecraft accommodation studies to determine which architecture best meets the requirements (including technical, cost and schedule requirements) while being compatible with the operations concept. The results of the accommodation studies are formally documented and are available in the GLAST Project office.

This process of refining the design through analysis and trade studies continues throughout Phase A and Phase B until MPDR. The lead person conducting the trade study is responsible for documenting the trade study either in a brief white paper, power point chart, or other appropriate form. The information contained in the white paper includes a summary of the trade, analysis performed, factors leading to the result, and the conclusion.

2.3.2 Architecture and Design Reviews

There are two major reviews related to the Mission Architecture and Design activities during Formulation: the System Concept Review (SCR) and the PDR. The SCR is held during Phase B and will ensure that the baseline architecture and design meets the requirements. The PDR is held at the end of Phase B and will ensure that the architecture, block diagrams, and interfaces are defined in enough detail as to proceed to Phase C without risk of major changes.

2.4 VERIFICATION

End-to-end mission system verification is the responsibility of the GLAST Project Office and is lead by the Project systems engineering team. Observatory verification planning, execution, and coordination is contracted to Spectrum Astro. This includes Observatory integration and test and on-orbit checkout. SLAC and MSFC are responsible for establishing and carrying out the verification plans for the LAT and GBM, respectively. The systems team uses the mission verification program to ensure that the GLAST system is "built right" and satisfies mission functional and performance requirements. The GLAST Systems Verification Plan (433-PLAN-0005) documents the methodology planned to verify system functionality and compliance with mission requirements. The GLAST systems team emphasizes test as the preferred method of verification, with the other allowable methods being analysis, inspection and demonstration. Each requirement and associated verification method is assigned an owner by SRR. The owner is responsible for specifying the method of verification no later than PDR. The Project Systems Engineering Team reviews and approves the instrument, spacecraft, and observatory verification plans methods and is responsible for establishing the verification plan for mission level requirements.

2.4.1 Verification Products

2.4.1.1 Verification Matrix. The Verification Matrix is developed at the time the requirements are written. This is a simple spreadsheet identifying the method of verification (analysis, test, inspection, demonstration). The verification matrix is used to develop the Verification Plan.

2.4.1.2 Verification Plan. The Verification Plan is a detailed document stating how each requirement is verified. The plan includes the Ground Support Equipment, Bench Test Equipment, Engineering Units, tools, facilities, etc. required to verify each requirement. The owner of each requirement is responsible for generating a verification plan for their assigned requirements by the PDR.

2.5 INTERFACES AND ICDS

During Phase A and early Phase B, the Systems Engineering Team define the *major* interfaces and assigns owners responsible for generating the ICDs. Interface Requirements Documents (IRDs) between the spacecraft and the instruments are also written during this period. The IRDs are maintained under Project configuration control. The spacecraft prime contractor is responsible for generating the Interface Control Documents (ICDs) between the spacecraft and the instruments, the observatory and the ground network, and the observatory and the launch vehicle. The spacecraft prime contractor writes a CDRL containing information related to the observatory to space network interface. This CDRL is used as input to the Observatory to Space Network ICD written by the GSFC Mission Services Office. The mission systems engineering team writes and maintains the LAT to GBM instrument ICD. The MOC contractor is responsible for generating the ICDs between the ground system elements. All ICDs are deliverables to the Project for approval.

2.6 RESOUCE BUDGETS AND ERROR ALLOCATION

2.6.1 Resource Budgets

The Project Office systems team is responsible for managing and tracking mission resource budgets and margins. These include mass, power, data volume etc. Spectrum Astro, as the observatory integrator, is responsible for tracking the observatory level resources. All resources and budgets are tracked by Spectrum Astro and presented at each Monthly Program Status Review. Each element System Engineer is responsible for tracking their resources in accordance with the system budget.

2.6.2 Pointing Knowledge Error Allocation Budget

The Project Systems Engineering Team is responsible for establishing and maintaining the pointing knowledge error allocation budget. During Pre-Phase A, the Integrated Design Team establishes a draft top down error allocation budget and iterates it with the key subsystems to see if the allocation is feasible. A baseline error allocation budget is established during Phase A. The error allocation budget is documented in the MSS.

2.6.3 Margin Management Philosophy

The Project Systems Engineering Team is responsible for allocating and maintaining technical resource margins. During Pre-phase A and Phase A, the Project Systems Engineering Team will hold a 30 percent margin on technical resources. Past experience shows that 25 percent of the total margin is allocated by the PDR and an additional 25 percent is allocated by the CDR. The Project Systems Engineering Team will follow these guidelines when reviewing the margin budgets throughout the GLAST lifecycle.

2.7 RISK MANAGEMENT

2.7.1 Risk Management Plan

The Risk Management Plan identifies the process to be used for the management of risks to the definition and implementation of the mission, including technical, cost, schedule, and programmatic. The GLAST Risk Management Plan is documented in 433-PLAN-0002.

2.8 ENVIRONMENTAL KNOWLEDGE

The environmental requirements that apply to all flight segment elements are established by the ISET and are documented in the MSS. Electromagnetic Compatibility and Electromagnetic Interference (EMI/EMC) requirements are established by an Electromagnetic Compatibility Advisory Board (EMCAB) and documented in 433-RQMT-0005 EMI Requirements Document. The EMCAB is a formal assembly of the GLAST Project Office, the spacecraft contractor, instrument providers, and, when necessary, the subcontractors and vendors.

2.9 CONFIGURATION MANAGEMENT

2.9.1 Configuration Management System

The GLAST Configuration Management (CM) system maintains, controls and disseminates the Project baseline. The GLAST CM system is documented in 433-PROC-0001 CM Procedure. In addition, the spacecraft contractor and instrument providers each have documented CM systems for the control of lower level specifications, plans, interface documents, and drawings.

2.9.2 Configuration Control Board

The Configuration Control Board (CCB) controls changes to the baseline, assesess the impact of design changes and ensures that authorized changes are implemented efficiently. The CCB reviews all Configuration Change Requests (CCRs) written by development team engineers, and is the final authority for all changes. The CCB is chaired by a representative from the GLAST Project Office, with the other members representing cost, schedule, Systems Engineering, CM, and *ad hoc* engineers. *Ad hoc* engineers are called in as needed to support evaluation of individual CCRs, depending on the topic. Composition of the CCB is defined in 433-PROC-0001 CM Procedure.

2.10 COMMUNICATION

Given the complexity of the interactions of GLAST, the diverse proximity of the team members, and challenging technical endeavors, open communication between all GLAST members is essential for the success of the GLAST mission.

2.10.1 Technical Interface Meetings (TIM)

The Project Systems Engineering Team conducts Technical Interface Meetings (TIM) as needed on specific topics that require involvement of more than one of the GLAST partner organizations.

2.10.2 Weekly ISET Teleconferences

The Project Systems Engineering Team conducts a weekly telecon of the ISET. The purpose of these telecons is to status and coordinate all systems engineering issues at the level of the Project and end-to-end mission.

2.10.3 Weekly SC-Instrument Interface Teleconferences

The spacecraft contractor conducts a weekly telecon with GLAST Project and the instrument providers. The purpose of the telecons is to coordinate the engineering of the interfaces between the SC and the instruments. Minutes and actions are published and tracked on a web site that is maintained by the spacecraft contractor.

2.10.4 Project Web Sites

Web sites are maintained by the GLAST Project Office, Spectrum Astro, the instrument development teams, and various subsystem providers. Links to all these sites can be found at: http://glast.gsfc.nasa.gov/resources/links.html.

2.11 LESSONS LEARNED

As part of the systems engineering process, it is important to not only extract lessons learned from previous missions, but to provide lessons learned on GLAST to the NASA community. The Project Systems Engineering Team will periodically review the NASA lessons learned database for items applicable to the GLAST Project. Lessons learned will be actively solicited from all members of the GLAST team, contractor and civil servant, and input into the NASA CH-01 lessons learned database. These lessons learned will also be shared at the Project monthly reviews to ensure that all team members have been made aware of them.

2.12 GLAST UNITS POLICY

The NASA Units Policy is contained in NASA NPD 8010.2 "Use of the Metric System of Measurement in NASA Programs". A brief summary of this policy can be condensed to the following:

- Flight projects should adopt metric measurements as the preferred system of weights and measures
- Controlled use of hybrid units is permitted where full implementation of the metric system is not feasible

Section 3.1.1.7 Units of Measurement of the GLAST Mission Systems Specification requires the following:

> GLAST shall observe the current NASA policy directive, NPD 8010.2C, Use of the Metric System of Measurement in NASA programs.
>
> Metric units shall be used with the following exceptions: Angular measure may be expressed in degrees, minutes, and seconds; Photon and particle energy may be expressed in eV; and English units may be used for mechanical fabrication.

These Mission requirements will be implemented with the following guidelines: CH-01

a. Flight & Ground Operational Software shall use exclusively Metric units (includes Flight operational products & deliverables, such as algorithms and analysis)
   - Rationale: Limits opportunity for error in system with highly complex verification process; difficult to find flight units errors prior to flight; various combinations of components & parameters may not be completely exercised or tested
b. ICDs may use metric units with English equivalent where necessary (typical for some mechanical items and Launch Vehicle)
   - Areas that are more easily verified via ground inspection, assembly, testing prior to flight
c. Manufacturing drawings can be English to enable use of US manufacturing facilities
d. Identify where Metric units are not used per NASA NPD 8010.2C.

The plan for the prevention of misapplication of units is implemented/tracked by the Systems Engineering team and is summarized below:

a. Identify categories where units error could result in loss of mission (ICDs, drawings, analysis, models, etc)
   - Identify in each subsystem where units error could cause mission loss; initial list required by spacecraft CDR
b. Decide and document areas where ground verification and testing may not catch units error
   - Reviews, inspections, tests; Identify areas where ground testing might not catch errors where English units are misapplied

c. Track the defenses against misapplication of units; Correct identified potential mission critical units errors CH-01
   - Utilize spreadsheet or database to record and track items

3.0 GLAST DOCUMENTATION STRUCTURE

Figure 3-1 shows the documents that are controlled under the GLAST configuration management system and how they relate to other Level III documents that are developed and maintained under CM control by the spacecraft, instrument, or launch vehicle provider. Table 3-1 gives a summary of the contents and ownership of the Project Office documents.

Figure 3-1. GLAST Project Controlled Document Tree

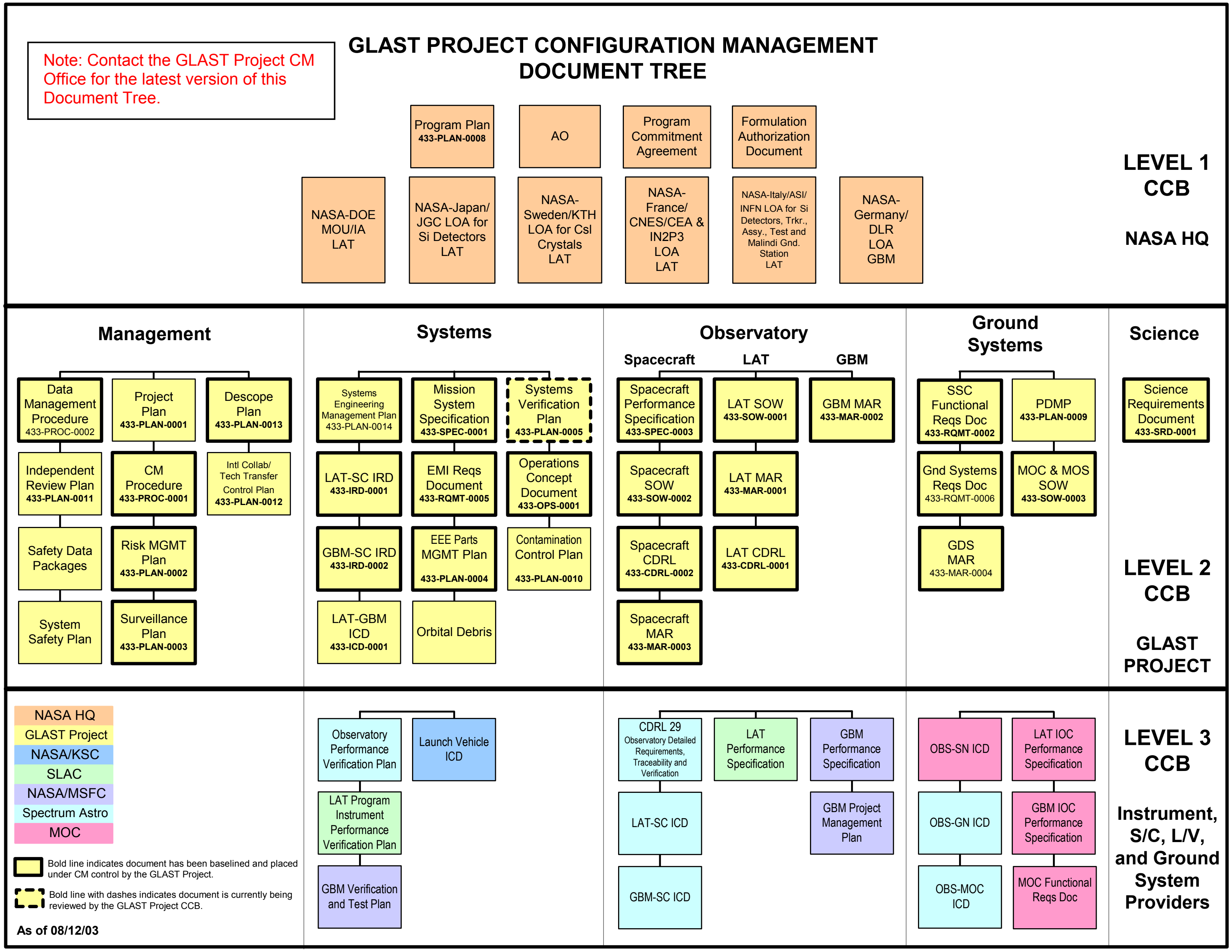

Table 3-1. GLAST Document Table

Document	Purpose/Content	Custodian	Signoff
433-PLAN-0001 Project Plan	Establishes the overall baseline for implementation as well as agreements among the Lead Center Director (LCD), Program Manager, Project Manager, and the involved NASA Center managers.	Project Manager	Project Manager SEU/NMP Program Manager GSFC Director
433-PLAN-0002 Risk Management Plan	Identifies the process to be used for the management risks to the definition and implementation of the mission, including technical, cost, schedule, and programmatic boundaries.	Risk Manager	Project Manager
433-PLAN-0003 Surveillance Plan	The purpose of this plan is to define the overall approach for surveillance of the contractor and partners activities on the GLAST program. The objective of the contractor and partners surveillance is to measure the health of the project through participation in their activities and collection and analysis of metrics of their performance.	System Assurance Manager	Project Manager
433-PLAN-0004 EEE Parts Management Plan	The EEE plan establishes and describes the duties of the GSFC Project Parts Engineer (PPE) in support of the GLAST Electrical, Electronic, and Electromechanical (EEE) parts program to assure all parts selected for flight hardware meet mission performance and reliability objectives.	Parts Engineer	System Assurance Manager Project Manager
433-PLAN-0008 GLAST Program Plan and Level 1 Requirements	Defines program objectives, authority and management structure, schedule, resources and controls. Describes relationships to other programs and agreements. Serves as the top level for the requirements flow-down. It defines basic mission parameters, constraints, and programmatic boundaries. (e.g., top-level science and mission requirements, external agreement requirements, and NASA/DOE constraints.)	Project Manager (PM)	SEU/NMP Program Manager GSFC Director Associate Administrator for Space Science

Table 3-1. GLAST Document Table (contd.)

Document	Purpose/Content	Custodian	Signoff
433-PLAN-0011 Independent Review Plan	Identifies the process to be used to provide independent review of the GLAST program. Identifies the independent reviews, defines the purpose and objectives of each, and provides a schedule of the reviews.	Project Manager	GLAST Project Manager SEU/NMP Program Manager Deputy Director for Systems Management GSFC Program Management Council Chair
433-PLAN-0014 System Engineering Management Plan (SEMP)	Describes the activities to be performed by NASA's GSFC Project Systems Engineering Team in support of the GLAST mission.	Systems Manager	Project Manager
433-PROC-0001 CM Procedure	Identifies the Configuration Management (CM) processes including the various boards and responsibilities, and provides the processes including the forms and board chairmanship.	Configuration Manager	Project Manager
433-SRD-0001 Science Requirements Document	Defines Level II science requirements for the LAT and GBM instruments and science-driven mission requirements.	Project Scientist	Project Scientist Project Manager LAT Principal Investigator GBM Principal Investigator
433-OPS-0001 Operations Concept Document	Provides the functional model and associated operational scenarios upon which the model operates. Data flow diagrams, data dictionary, functional description, and operational scenarios are also included in this document. This is not a requirements document, but rather a source document from which mission requirements are derived.	Operations Manager	Project Manager

Table 3-1. GLAST Document Table (contd.)

Document	Purpose/Content	Custodian	Signoff
433-SPEC-0001 Mission System Specification (MSS)	The MSS contains top-level mission specifications and description of the mission, system, and interfaces between Level 3 components. The MSS contains Level 2 mission functional and performance requirements, which when met by the system, will satisfy the Level 1 requirements and mission objectives. The MSS contains all requirements that cross between Level 3 elements, including error allocations, control loops, etc. The MSS includes mission-level environmental requirements and orbit parameters. The MSS provides top-level requirements for the lower-level documents.	Mission Systems Engineer (MSE)	Project Manager Project Scientist
433-SPEC-0003 S/C Performance Specification	The SPS provides the functionalities and the key performance requirements for the GLAST spacecraft.	Observatory Manager	Project Manager
MOC Functional Requirements Document	This document defines the functional requirements that must be met by the GLAST Mission Operations Center (MOC)	Mission Operations and Ground Systems Development Manager	GSOM
433-RQMT-0002 SSC Functional Requirements Document	This document defines the functional requirements that must be met by the GLAST Science Support Center (GSCC)	GSSC Science Lead	Project Manager
433-RQMT-0005 EMI Requirements Document	The Electromagnetic Interference (EMI) Requirements document defines the overall approach and design criteria to ensure compatible operation of the GLAST Observatory. The document provides the EMI requirements and management organization procedures for the prime contractor, subcontractors and vendors as it relates to EMC control. The document identifies the particular requirements in the design area for bonding, grounding, and shielding to control radiated and conducted emissions and susceptibility to specified EMI/EMC levels.	Electrical Discipline Engineer	Project Manager
433-RQMT-0006 Ground System Requirements Document	This document defines the requirements that must be met by the GLAST ground system.	Mission Operations and Ground Systems Development Manager	Project Manager

Table 3-1. GLAST Document Table (contd.)

Document	Purpose/Content	Custodian	Signoff
433-IRD-0001 LAT Instrument-SC IRD	LAT-SC IRD describes and specifies the mechanical, electrical and data interfaces between the LAT instrument and the spacecraft. In addition, it assigns certain interface responsibilities and provides design guidelines in certain areas.	LAT Instrument Manager	Project Manager
433-IRD-0002 GBM Instrument-SC IRD	GBM-SC IRD describes and specifies the mechanical, electrical and data interfaces between the GBM instrument and the spacecraft. In addition, it assigns certain interface responsibilities and provides design guidelines in certain areas.	GBM Instrument Manager	Project Manager
433-MAR-0001 LAT MAR	The LAT MAR defines the Safety and Mission Assurance requirements for the LAT instrument.	System Assurance Manager	Project Manager
433-MAR-0002 GBM MAR	The GBM MAR defines the Safety and Mission Assurance requirements for the GBM instrument.	System Assurance Manager	Project Manager
433-MAR-0003 Spacecraft MAR	The Spacecraft MAR defines supplemental Safety and Mission Assurance requirements for the GLAST delivery order under the RSDO Rapid II contract.	System Assurance Manager	Project Manager
433-MAR-0004 GDS MAR	This document, referred to as the “Ground Data System MAR,” defines the Safety and Mission Assurance (S&MA) requirements for the GLAST Ground Data System (GDS). Additional mission assurance requirements are defined in the Statement of Work (SOW).	System Assurance Manager	Project Manager

4.0 INTEGRATED SYSTEMS ENGINEERING TEAM AND WORKING GROUPS

This section describes the GLAST Integrated Systems Engineering Team (ISET) and working groups that will execute the development of the system engineering products.

4.1 INTEGRATED SYSTEMS ENGINEERING TEAM

GLAST presents many systems engineering challenges. The following issues contribute to these challenges:

- Complex interactions between subsystems

- Science instrument development phasing significantly different from spacecraft
- Subtle interactions inside subsystems that affect the system
- System engineering activities are occurring across the globe

To ensure the success of GLAST, the system perspective is essential throughout all phases of the mission. Each engineer must be knowledgeable of the effects produced by their subsystem on the overall system. Managing these interactions is a great challenge to the Project Systems Engineering Team.

To meet this challenge, the Project Systems Engineering Team set up an ISET. The ISET orchestrates the evolution of the GLAST design throughout all phases of the mission. During the Formulation phase, the ISET develops and defines the architecture; makes key architecture decisions; develops and defines the operations concept; defines, conducts, and leads trade studies; and verifies the architecture and operations concept against the requirements.

Throughout the design phase the ISET provides oversight for the GLAST working groups and coordinates science related issues with the GLAST science team. Technical agreements are achieved in the working groups and brought to the ISET for ratification. The ISET determines if the agreements represent changes in the baseline requirements and, if so, coordinates changes to the Project requirements.

The Mission System Engineer MSE chairs the ISET. It is comprised of engineers and scientists from GSFC, MSFC, SLAC, and Spectrum Astro. Project office membership, in addition to the MSE, includes the Deputy Project Scientist, Systems Manager, Spacecraft SE, and Ground SE. Minutes and action items are kept by the Project Office and published on the Spectrum Astro GLAST web site. Other working groups are form per the direction of the ISET. The working groups address specific issues. Key scientists and engineers staff the working groups as appropriate.

4.2 SYSTEM ENGINEERING WORKING GROUPS

The ISET provides oversight for the Thermal/Mechanical Interface Working Group, Electrical/Data Interface Working Group, GLAST Operations Working Group, Integration and Test Working Group, and the Pointing Working Group and coordinates science related issues with the GLAST science team. The working groups are formed and dismantled as needed.

4.2.1 Thermal/Mechanical Interface Working Group

The Thermal/Mechanical Interface Working Group coordinates the definition of the thermal and mechanical aspects of the interfaces between the GLAST spacecraft and the LAT and GBM science instruments. It is made up of engineers from the Project Office, Spectrum Astro, MSFC, and SLAC. Representatives from subcontractors participate as needed. Minutes and action items are kept by Spectrum Astro and published on the Spectrum Astro GLAST web site. The Thermal/Mechanical Interface Working Group supports the development of the SC-LAT and SC-GBM ICDs.

4.2.2 Electrical/Data Interface Working Group

The Electrical/Data Interface Working Group coordinates the definition of the electrical, power, command, and telemetry aspects of the interfaces between the GLAST spacecraft and the LAT and GBM science instruments. It is made up of engineers from the Project Office, Spectrum Astro, MSFC, and SLAC. Representatives from subcontractors participate as needed. Minutes and action items are kept by Spectrum Astro and published on the Spectrum Astro GLAST web site. The Electrical/Data Interface Working Group supports the development of the SC-LAT and SC-GBM ICDs.

4.2.3 GLAST Operations Working Group

The GLAST Operations Working Group (GOWG) coordinates the development of the operations plans and procedures required for the GLAST system. The GOWG is chaired by the Mission Operations and Ground Systems Development Manager. It is made up of engineers from the Project Office, Spectrum Astro, MSFC, SLAC, MOC contractor, GSSC, and LAT and GBM IOCs. The GOWG supports the development of the GLAST Operations Concept and Project command and telemetry data base.

4.2.4 Integration and Test Working Group

The Integration and Test Working Group coordinates the definition of the GLAST observatory integration and test plan and procedures. The Integration and Test Working Group is chaired by the Spectrum Astro Integration and Test Lead. It is made up of engineers from the Project Office, Spectrum Astro, MSFC, SLAC, and MOC. Representatives from subcontractors participate as needed. Minutes and action items are kept by Spectrum Astro and published on the Spectrum Astro GLAST web site. The Integration and Test Working Group supports the development of the plans and procedures required to integrate the science instruments, spacecraft, space network, ground network, and mission operations center into the complete GLAST observatory.

4.2.5 Pointing Working Group

The Pointing Working Group coordinates issues related to meeting the overall GLAST observatory pointing requirements. The Pointing Working Group is chaired by the Spectrum Astro Systems Engineering Lead. It is made up of engineers from the Project Office, Spectrum Astro, MSFC, and SLAC. Representatives from subcontractors participate as needed. Minutes and action items are kept by Spectrum Astro and published on the Spectrum Astro GLAST web site. The Pointing Working Group supports the development of interface requirements, analysis plans, and and I&T procedures required to integrate the science instruments and spacecraft and verify the GLAST pointing requirements.

5.0 SYSTEM ENGINEERING MANAGEMENT

5.1 PROJECT SYSTEMS ENGINEERING TEAM

The Project Systems Engineering Team is organizationally located in the GLAST Project. The organization chart for the GLAST Project is available on the GLAST Project web site at: http://glast.gsfc.nasa.gov/project

The Project Systems Engineering Team is responsible for ensuring the technical cohesiveness of all individual project elements. It is responsible for establishing the overall framework and procedures for management of the GLAST technical requirements, design process, and the verification process, and for orchestrating the evolution of the design through all phases of the mission.

5.2 SYSTEMS ENGINEERING TEAM FUNCTIONS

The following functions are performed by members of the GLAST Project systems engineering team.

5.2.1 Systems Management

Systems management functions are performed by the Mission Systems Manager. These functions include: Leading the GLAST System Engineering Team and managing the overall success of GLAST System Engineering; Resolving issues between segments: Coordinating issues/progress with Project Management; Manageing the SEMP; Developing the technical documentation hierarchy, including signoff structure for documents.

5.2.2 Mission Systems Engineering

Mission Systems Engineering Functions are performed by the Mission Systems Engineer. These functions include: Chairing the Integrated Systems Engineering Team; Leading and coordinating the definition of the system architecture, design, and operations concept; Managing error budgets, performance budgets and margin allocations for system resources; Managing the Mission System Specification (Level 2 Requirements).

5.2.3 Requirements Systems Engineering

Requirements Systems Engineering functions include: Providing guidelines and procedures for GLAST technical requirements flow-down; Establishing the procedures and tools to be used for requirements tracking; Maintaining the system for tracking GLAST requirements and verification matrices.

5.2.4 Flight Software Systems Engineering

Flight Software Systems Engineering functions include: Defining overall software architecture strategy; Writing guidelines and procedures pertaining to software; Coordinating software Independent Verification and Validation (IV&V) activities.

5.2.5 Risk Management Coordination

Risk Management Coordination functions include: Developing the Risk Management Plan; Coordinating all risk management activities, including documentation, tracking, and mitigation plans.

5.2.6 System Assurance Management

The System Assurance Management function is responsible for assuring the performance reliability of all flight and ground system segments of the GLAST mission.

5.2.7 Spacecraft Systems Engineering

Spacecraft Systems Engineering functions include: Working with the Observatory Manager to allocate requirements from the GLAST MSS to the SPS; Resolving spacecraft level technical issues; Maintaining the spacecraft to instrument IRDs.

5.2.8 Instrument Systems Engineering

Instrument Systems Engineering functions include: Supporting the Integrated Design Team; Developing the instrument architecture in concert with the instrument team to respond to higher level requirements and specifications; Allocating requirements from the MSS to the instrument requirements documents; Maintaining the spacecraft to instrument IRDs in concert with the spacecraft systems engineering function.

5.2.9 LAT On-Site Systems Engineering

LAT On-Site Systems Engineering functions include: Representing GLAST Project systems engineering on the LAT systems engineering team; Supporting the LAT systems engineering team; Facilitating communication between the Project and LAT systems engineering teams.

5.2.10 Integration and Test Management

I&T Management functions include: Planning and implementing the End-to-End I&T activities, including final acceptance.

5.2.11 Launch Vehicle System Engineering

Launch Vehicle System Engineering functions include: Interfacing with the launch site, in support of procurement, budgeting, planning and scheduling, and other actions necessary for designing, developing, fabricating, testing, modifying, launching, and tracking the launch vehicle through the orbit transfer trajectory insertion.

ACRONYMS

CCB	Configuration Control Board
CCR	Configuration Change Requests
CDR	Critical Design Review
CM	Configuration Management
EEE	Electrical, Electronic, and Electromechanical
EMC	Electromagnetic Compatibility
EMCAB	Electromagnetic Compatibility Advisory Board
EMI	Electromagnetic Interference
GBM	GLAST Burst Monitor
GEVS-SE	General Environmental Verification Specification for STS and ELV Payloads, Subsystems and Components
GLAST	Gamma-ray Large Area Space Telescope
GOWG	GLAST Operations Working Group
GSFC	Goddard Space Flight Center
GSSC	GLAST Science Support Center
I&T	Integration and Test
ICD	Interface Control Document
IOC	Instrument Operations Center
IPO	Instrument Program Office
ISET	Integrated Systems Engineering Team
IRD	Interface Requirements Document
MAR	Mission Assurance Requirements
MOC	Mission Operations Center
MSFC	Marshall Space Flight Center
MSS	Mission System Specification
LAT	Large Area Telescope
PDR	Preliminary Design Review
RSDO	Rapid Spacecraft Development Office
SC	Spacecraft
SCR	System Concept Review
SE	System Engineer
SLAC	Stanford Linear Accelerator Center
SOW	Statement of Work
SPS	Spacecraft Performance Specification
SRD	Science Requirements Document
SRR	Systems Requirements Review
TBD	To Be Determined
TBR	To Be Resolved
TBS	To Be Supplied
TIM	Technical Interchange Meeting